FRDA Memo

November 1996 No. 240

Mixedwood Management Research in British Columbia: A Summary of Research Initiatives

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Index of Mixedwood Management Projects[a]

Topic	Tree species							
	Trembling aspen	Paper birch	Red alder	Bigleaf maple	Black cottonwood Balsam poplar	Hybrid poplar	Other	All species
Ecology	H08, H19, H28, FR14, B16, B35	H05, H06, H19, H23, H24, H25, H28, FR42, FR47	H06, H08, H28, H29, B39, FR53	H06	H19, H28		H30	
Genetics			FR38					
Regeneration	H09, B34	FR47, FR47a, B34			B34, B40			
Stand tending	B20	H05, B12, B20	H14, FR12, B07		B20	H07, H12, H13		
Silviculture systems	H17, B16							
Forest health		FR47	H33		B37	H34, B37		
Growth and yield	H27	H05, FR42	H08, H14, FR53, B07					H02, H04
Biodiversity and non-timber resources	B18, B28, B45	B45			B45		H31	

[a] Mixedwood management research projects under way in B.C. during 1995/1996 arranged by topic and species (H = FRBC funded project; B = FRDA Subprogram 1.3 funded project; FR = FRDA Subprogram 3.1 funded project).

Index of Mixedwood Management Projects[a] by Forest Region

Forest region	Tree species						
	Trembling aspen	Paper birch	Red alder	Bigleaf maple	Black cottonwood Balsam poplar	Hybrid poplar	Other
Cariboo	B34, B35	B34			B34		
Kamloops		H23, H24, H25, B12, FR42, FR47, FR47a					
Prince George	H09, H17, H19, H27, FR14, B16, B18, B20, B28, B45	H05, H19, B20			H19, B20		
Prince Rupert			H04, H33, B39, FR38				
Vancouver			H04, H29, H33, FR38, FR53, B07	H06		H07, H12, H13, B40	H30, H31
All over B.C.	H02, H08, H19	H02, H08, H19	H02, H08, H19, FR12		H02, H19	H34, B37	

[a] Mixedwood management research projects under way in B.C. during 1995/1996 arranged by forest region and tree species (H = FRBC funded project; B = FRDA Subprogram 1.3 funded project; FR = FRDA Subprogram 3.1 funded project).

INTRODUCTION

Six major broadleaf tree species found in B.C. in both pure and mixed stands are: trembling aspen, paper birch, balsam poplar, black cottonwood, red alder, and bigleaf maple. In addition, hybrid poplars are being grown in the lower mainland, on Vancouver Island, and in the southern interior of B.C. Approximately 1.9 million m^3 (0.6 million m^3 of red alder in the southwest and 1.3 million m^3 of aspen in the northeast) of broadleaf trees are commercially harvested in the southwestern and northeastern parts of B.C. each year. Available data suggest the potential to harvest in excess of 7 million m^3 of broadleaves per year from broadleaf-dominated stands, and additional volume could be obtained through the utilization of broadleaves in mixed stands. This would create close to 20 000 direct and indirect jobs and generate $475 million in employment income each year. There would be additional opportunities for job creation and generation of value-added revenue through secondary industries such as manufacturing moldings, furniture, and other specialty products.

Mixed stands composed of both broadleaves and conifers are found in many parts of B.C. The management of these mixed stands can be difficult due to differences in rates of growth between broadleaf and conifer species. Where broadleaves regenerate to very high densities, they may preclude conifer growth. However, at low and intermediate broadleaf densities, understory conifers may grow at acceptable rates. Growing mixed-species stands can have many benefits including increased nutrient cycling, improved availability of nitrogen, nitrogen fixation (red alder), increased yield, healthier forests, increased biodiversity, improved wildlife habitat, and visual esthetics. In order to sustainably manage B.C.'s broadleaf and mixedwood forests and maintain both timber and non-timber resource values, more local information and experience is required to guide decision-making.

The Hardwood and Vegetation Management Technical Advisory Committee was established by the B.C. Ministry of Forests in 1990 to assist in developing and implementing a long-term, coordinated research and extension program in broadleaf and vegetation management. This Technical Advisory Committee has been actively involved in the implementation of broadleaf, mixedwood, and vegetation management research supported by the Canada–British Columbia Partnership Agreement on Forest Resource Development (FRDA II) since 1991, and by Forest Renewal B.C. (FRBC) during 1995 and 1996.

Mixedwood Management Research in B.C.

Mixedwood management research in B.C. is focused in the following areas:

1) genetics of major broadleaf species (diversity, adaptability, and selection for growth, form, and quality);
2) regeneration of broadleaves (natural regeneration, production of quality planting stock, site preparation, plantation espacement, stocking and free-growing standards);
3) stand tending requirements in broadleaf stands (vegetation management, juvenile spacing, pruning, commercial thinning);
4) mixedwood silviculture systems;
5) forest health (incidence, impact and management of insects and diseases);
6) ecology (site selection, stand dynamics, nutrient cycling, interactions between broadleaves and conifers, nurse crop effects, biodiversity);
7) growth and yield (productivity, yield tables for natural and managed pure and mixed stands, field demonstrations and models, wood quality); and
8) impacts of utilization and management on biodiversity and non-timber resource values associated with broadleaf and mixedwood stands.

For More information on Mixedwood Management Research, contact individual project leaders or Dr. Phil Comeau, B.C. Ministry of Forests, Research Branch.

I. FRDA II—Subprogram 1.3: Mixedwood Management Research

B07 Stand tending regimes for red alder (*Alnus rubra*) plantations (E.P. 1140.01)

Project Leader:
Paul Courtin, B.C. Ministry of Forests, Vancouver Forest Region.

Objectives:

The purpose of this study is to examine the effects of plantation espacement, juvenile spacing, and pruning on the growth and yield of red alder. Installations have been established at locations in B.C., California, Oregon, and Washington by the Hardwood Silviculture Cooperative (HSC). Data will be collected in cooperation with the HSC for the modelling and prediction of red alder growth and yield in the Pacific Northwest.

Progress:

The Campbell River installation is into its fourth growing season and 3rd-year growth measurements have been collected. The French Creek plantation (planted in 1994) has had some mortality due to drought. The Lucky Creek plantation (near Ucluelet) was replanted with approximately 500 seedlings, replacing the Sitka alder that were originally planted. A regeneration survey at both French Creek and Lucky Creek was completed before the start of the 1996 growing season. Growth measurements will commence in the fall of 1996.

B12 Pure and mixed paper birch stand management studies in the ICH zone in the southern interior of British Columbia: birch thinning trials (E.P. 1089.02)

Project Leader:
Suzanne Simard, B.C. Ministry of Forests, Kamloops Forest Region.

Objectives:

The purpose of this study is to examine the response of 15-year-old paper birch to a range of thinning intensities and to evaluate the effects of density reduction treatments on the growth and yield of paper birch. The study will also provide preliminary data for the development of yield tables for managed birch stands.

Progress:

Four installations have been established in the Kamloops Forest Region. Measurements in various treatments at each of the four thinning trials included measures of light attenuation, leaf area, and photosynthesis of birch and understory Douglas-fir. Light saturation curves are being developed for paper birch and interior Douglas-fir seedlings. Nitrogen fixation data were collected and differences between thinning densities and pure paper birch and pure Douglas-fir stands were detected. Analysis of 3rd-year growth response to thinning is almost completed. It is anticipated that the results of this study will be submitted in 1996/1997 as a paper in a refereed journal.

Publications:

Wang, J.R., S.W. Simard, and J.P. Kimmins. 1995. Physiological response of paper birch to thinning in British Columbia. For. Ecol. Manage. 73: 177–184.

B16 (FR54) Investigations of planting white spruce under trembling aspen

Project Leader:
Craig DeLong, B.C. Ministry of Forests, Prince George Forest Region.

Objectives:

To examine the growth of white spruce planted under an aspen canopy, and to compare this to growth in a clearcut environment. To develop site selection and appropriate nursery and site preparation criteria to ensure optimum survival and growth of spruce planted under aspen.

Progress:

The first phase of this project, completed in March 1991, summarized existing underplanting trials and looked at reasons for success or failure. Phase 2 examined the microenvironment under aspen canopies of different structures to determine the conditions under the canopies. Phase 3 was initiated in 1992. This phase involves the development of nursery regimes to adapt tree seedlings to the environment under an aspen canopy and the monitoring of outplantings of these seedlings under canopies offering the most favourable microclimate. The seedlings will also be compared to those planted in clearcuts. To date, 3rd-year survival and morphological measurements have been collected and are being analyzed. A microclimate station was set up in the clearcut and in the aspen understory. It is hoped that the microclimate data will help elucidate the different growth responses of the white spruce growing under the different regimes.

Publications:

Tanner, D., S.C. Delong, and A. Eastham. 1996. Investigations of planting white spruce under a trembling aspen canopy. *In* Silviculture of Temperate and Boreal Broadleaf-conifer Mixtures, held Feb. 28 and Mar. 1, 1995 in Richmond, B.C. P.G. Comeau and K.D. Thomas (editors). B.C. Min. For. Land Manage. Handb. 36. p. 114–121.

Shortreid, A. (editor). 1991. Northern mixedwood '89: Proceedings of a symposium held at Fort St. John, B.C., Sept. 12–14, 1989. For. Can. and B.C. Min. For., Victoria, B.C. FRDA Rep. No. 164.

B18 Integrated aspen-range resource management options in the BWBS zone; The effects of timber harvesting, agronomic seeding, and cattle grazing on aspen and forage production in the South Peace Region (E.P. 1075.01)

Project Leader:

Winn Hays-Byl, B.C. Ministry of Forests, Dawson Creek Forest District.

Objectives:

a) to determine the effects of summer and winter clearcutting of aspen parkland on (i) subsequent aspen sucker density and growth, and on (ii) native forage production;
b) to determine the effects of cattle grazing in winter- and summer-logged sites on aspen sucker density and growth;
c) to determine the effects of domestic grass seeding after harvesting on (i) total forage production and (ii) aspen sucker density and growth in summer- and winter-logged sites;
d) to determine the foliar nutrition of preferred forage species; and
e) to assess cattle weights as a means of ensuring animal weight gain in the controlled grazing.

Progress:

This project was initiated in 1991–1992 at three sites: summer-logged, winter-logged, and unlogged aspen parkland. Each site was split into a grazed and ungrazed area, and eight seeded subplots were systematically located within each grazing block. This experiment examined only one grazing rate (75%) and one seeding rate (10 kg/ha). Pre- and post-grazing re-measurement of vegetation within a total of 2160 permanent sample plots and pre- and post-grazing remeasurement of soil density within 144 treatment units has been done. Minor vegetation was collected for biomass determination, and foliar samples were collected for nutrient analyses. The effect of harvesting and grazing on soil compaction was also examined. Photographs have also been taken to help visually document this study. Preliminary findings have been presented at seminars and workshops, and a video was produced in conjunction with Louisiana Pacific Canada Ltd.

B20 Development of silvicultural techniques to maximize productivity of native northern hardwood monocultures (E.P. 1133.01)

Project Leader:

Dave Coopersmith, B.C. Ministry of Forests, Prince George Forest Region.

Objectives:

The objectives of this project are to evaluate and demonstrate the effects of a range of stand-tending strategies on the quantity and quality of broadleaf yield.

Progress:

Four trials have been installed: (1) Sierra–Fort Nelson (aspen spacing); (2) Muskwa–Fort Nelson (cottonwood plantation); (3) Del Rio–Chetwynd (aspen spacing); (4) Aleza Lake–Prince George (cottonwood plantation). A fifth trial is planned for Morkill in the Robson Valley. Plot layout and installation, pre-treatment measurements, and crop-tree numbering and thinning have been completed at four sites. Foliar samples were collected at Del Rio for nutrient analysis. The Muskwa site was replanted with cottonwood in the spring of 1995 due to a high winter mortality. The Aleza Lake site suffered losses to voles, but cottonwood whips are being rooted to infill the site.

B28 Changes in bird diversity and abundance following aspen clearcutting in the BWBS biogeoclimatic zone (E.P. 1168)

Project Leaders:
Scott Harrison, B.C. Ministry of Forests, Prince George Forest Region.
Art Lance, Industrial Forestry Service Limited.

Objectives:

This project examines the variety, abundance, and habitats of birds in boreal aspen forests subject to logging. The aim is to suggest a harvesting regime that will sustain both the bird community and the aspen timber supply. The study has included the following:

a) an inventory of the bird species in BWBS aspen woodland;
b) the effect of different cutblock sizes; and
c) the response of the bird community to aspen re-growth after logging.

Progress:

A review of the literature revealed that little attention has been given to the effects of logging on bird diversity and abundance in boreal aspen forest. Pilot fieldwork was completed in 1991 to design a study for 1992–1995. Thirty-two sample stands of aspen, in different sizes and re-growth stages, were sampled 15 times apiece in April–July 1992. Some 6400 observations on 74 species are now being analyzed stand by stand. The project was implemented in 1992, and final field season measurements were taken in 1995. Results from 1992–1995 are currently being analyzed.

Publications:

Lance A.N., R. Pojar, and M. Phinney. [1996]. Bird diversity and abundance in aspen forest in northern B.C. *In* Ecology and Management of B.C. Hardwoods. Workshop Proc. Dec. 1–2, 1993, Richmond, B.C. P.G. Comeau, G.J. Harper, M.E. Blache, J.O. Boateng and K.D. Thomas (editors). Can. For. Serv. and B.C. Ministry of Forests, Victoria. FRDA Report. In Press.

B34 Suitability of native hardwoods for reforestation and their effect on long-term soil nutrient status (E.P. 1136.01)

Project Leader:
Nola Daintith, B.C. Ministry of Forests, Cariboo Forest Region.

Objectives:

This study compares the survival and growth of three native broadleaf trees (aspen, paper birch, and black cottonwood) to lodgepole pine and interior spruce over a range of sites in the Cariboo Forest Region. The aim is to document the growth of these species and determine their susceptibility to *Armillaria* root rot, damage from mammals, and frost. The project will also study the effect of native broadleaves on long-term soil nutrient status, and provide information on appropriate spacing of broadleaves.

Progress:

Site selection, site preparation, and layout work were completed in 1992. All sites were planted in the spring of 1993. Soil sampling and description were completed in August 1993. Third-year height and basal stem diameter, seedling condition, and damage measurements were collected in the fall of 1995. The data have been analyzed and are available in a 3rd-year report. Various options

for protecting seedlings from wildlife and cattle are being considered.

B35 (FR59) Effects of aspen density and stocking on the performance of coniferous plantations in the Cariboo Forest Region (E.P. 1152)

Project Leader:
Teresa Newsome, B.C. Ministry of Forests, Cariboo Forest Region.

Objectives:

The effect of aspen density and stocking on plantation performance must be documented over time to determine if and when stand-tending activities are necessary. This study investigates and quantifies the effects of trembling aspen competition on lodgepole pine, identifies measures of competition to determine how trembling aspen competition is affecting lodgepole pine survival and growth, and monitors lodgepole pine survival and growth where partial removal is used.

Progress:

Phase 1 was a retrospective study that will provide information from field studies about stands with high aspen densities that may require stand tending to release conifers. Stands were surveyed to determine the variation in growth and condition of conifers growing under different aspen densities, and growing without excessive competition. Data collection for this phase is complete. Three sites in the IDFdk and three sites in the SBSdw were sampled. Vegetation, seedling, and light measurements were taken at approximately 50 plots at each site. Data analysis for phase 1 is in progress. An ecological description was done at each site. An annotated bibliography was completed on broadleaf-conifer interactions. Phase 2 involves monitoring and assessing pine seedlings growing with aspen from an initial establishment phase on a site for at least 10 years. Sites for this phase have been selected in areas where relatively dense aspen is expected to occur. Information still to be collected includes conifer height growth, diameter and condition, stocking and density of broadleaves and conifers, and average height and percent cover of aspen.

Publications:

Newsome, T.A. 1995. Assessing aspen competition on pine growth in the Cariboo Forest Region. *In* Proc. Northern Interior Vegetation Management Assoc. Annual Meeting, Jan. 18–19, 1995, Williams Lake, B.C. C. Farnden (editor). Can. For. Serv., Prince George, B.C. pp. 91–97.

B37 Development of diagnostic tools for poplar disease in British Columbia

Project Leader:
Brenda Callan, Pacific Forestry Centre, Victoria, B.C. Forestry Canada.

Objectives:

The increased interest in poplars as a source of pulp and wood products has not been complemented by up-to-date disease diagnostic information. The purpose of this study is to acquire baseline diagnostic information on diseases of native and hybrid poplars in B.C. Techniques and tools to enhance diagnostic accuracy, such as improved assay methods and identification manuals, will be developed. This information is fundamental to making accurate projections about productivity and management of this resource.

Progress:

Extensive collection, identification, and photography of pathology specimens is continuing. Several sites were revisited in the far northwest of the province, and new distribution record collections were identified and entered into the Herbarium. In Terrace, trees were rated for levels of two fungal blights *Linospora tetraspora* and an undocumented *Guignardia* species. At a clonal trial on Vancouver Island, nearly 1500 hybrid poplar trees were rated for four pests. This was done in conjunction with similar assessments in Oregon so that the data could be compared between locations. Identification of collections made in the field continues, and new records are being added to the host-fungus checklist. Two Forestry Canada Pest Reports have been

written: one about the U.S. hybrid poplar rusts (*Melampsora medusae* and *M. larici-populina*) and their potential for damage to Canadian trees, and the other about poplar pathology surveys and research in the Pacific Region. The disease diagnostic manual entitled 'Common diseases of *Populus* in British Columbia' is in the final stages of publication and should be available by the end of 1996.

Publications:

Callan, B.E. and F.M. Ring. 1994. An annoted host fungus index for *Populus* in British Columbia. Can. For. Serv. and B.C. Min. For. FRDA Rep. 222.

B39 The use of red alder to enhance Sitka spruce growth in the Queen Charlotte Islands (E.P. 1178)

Project Leader:

Paul Courtin, B.C. Ministry of Forests, Vancouver Forest Region.

Objectives:

The objectives of this study are (a) to determine the effect of varying admixtures of interplanted red alder on the productivity of Sitka spruce, on nutrient poor to medium sites on Graham Island; and (b) to monitor the effects of the red alder admixtures on chemical and physical soil properties, and on spruce foliar nutrients.

Progress:

The study consists of four randomly assigned treatments of varying densities of red alder, interplanted among Sitka spruce. The plots are replicated three times at two different locations. Sites have been established and 3100 spruce were planted and labelled. Alder stock was planted at two trial locations (Port Clements and Small Lake) in late 1992 and early 1993. Both sites were severely browsed, but Small Lake alder have survived. There was 95% alder mortality at the Port Clements site, so it was replanted in March 1995. Baseline soil chemistry and description, and foliar sampling were done following plantings. Third-year height and caliper measurements of the spruce and surviving alder were completed in March 1995.

B40 Poplar demonstration plantation at Surrey Nursery

Project Leader:

Tony Willingdon, B.C. Ministry of Forests, Surrey Nursery.

Objectives:

This project will demonstrate the potential for poplar culture in the lower mainland and provide measured comparisons of growth between irrigated and non-irrigated poplar plantations. It will also demonstrate the potential to utilize nutrient-rich waste water in poplar culture and to reduce runoff of potentially polluting effluent. This study will document the growth rates and characteristics of different poplar clonal types in south Surrey.

Progress:

The site was cleared and prepared in 1991, and 5000 cuttings were originally planted in 1992; however, due to heavy deer browse, the site was replanted with four different clonal types in April 1995. In order to control the invasion of weeds, sheep fescue was planted between rows and mowed. An irrigation system has also been installed to improve the transfer of nutrient-rich effluent to the plantation.

B45 Monitoring changes in wildlife diversity during silviculture systems trials and operational hardwood harvesting: aspen clearcutting in the Dawson Creek Forest District (E.P. 1170.01)

Project Leader:

Laura Darling, B.C. Ministry of Environment, Lands and Parks.

Objectives:

a) to assess the effect of aspen clearcutting in the BWBSmw1 and BWBSwk1 subzones in the Prince George Forest Region on wildlife diversity;
b) to determine the link between changes in wildlife diversity and changes in forest structure associated with aspen harvesting;
c) to contribute to guidelines for the maintenance of wildlife diversity in managed forests; and

d) to coordinate and encourage standardization of provincial data collection regarding the effects of the full range of silvicultural practices on wildlife diversity.

Progress:

This project was started in 1992 and will be completed in 1996/1997. Breeding-bird surveys and small-mammal trapping and habitat surveys have been done, and work is continuing at the study sites. Data have been analyzed and will be available in a progress report. A journal paper has been written and submitted to the Journal of Wildlife Management, and is currently under review.

II. FRDA II—Subprogram 3.1: Mixedwood Management Research

FR12 Membership in the Hardwood Silviculture Cooperative

Project Leader:

Paul Courtin, B.C. Ministry of Forests, Vancouver Forest Region.

Objectives:

The Hardwood Silviculture Cooperative, based at Oregon State University, has initiated an alder management study to examine spacing effects in natural stands and in plantations. The B.C. Forest Service is a member of this cooperative.

Progress:

Using the cooperative's guidelines, two installations for a study of spacing in natural stands, three installations for a study of plantation esprcement, and two alder–Douglas-fir replacement series installations have been established in the Vancouver Forest Region.

FR14 Northern mixedwood forests, the carbon cycle, and sustainable production (E.P. 1107)

Project Leaders:

Phil Comeau, B.C. Ministry of Forests, Research Branch, Victoria.

Dave Spittlehouse, B.C. Ministry of Forests, Research Branch, Victoria.

Objectives:

This project provides an estimate of the carbon budget of northern mixedwood forests, and will examine the effect of harvesting and prescribed burning. It has also examined the effects of different management strategies (broadleaf, mixedwood, and conifer) on the long-term productivity of boreal mixedwood forests.

Progress:

To estimate carbon budgets, available data pertaining to carbon cycling have been gathered. Field data on carbon content and distribution have been collected and summarized from 24 aspen and mixedwood stands in the Dawson Creek Forest District.

Publications:

Kurz, W.A., M.J. Apps, P.G. Comeau, and J.A. Trofymow. [1996]. The carbon budget of British Columbia's forests, 1920–1989: preliminary analysis and recommendations for refinements. Can. For. Serv. and B.C. Min. For. FRDA Rep. In press.

Wang, J.R., P.G. Comeau, and J.P. Kimmins. 1995. Simulation of mixedwood management of aspen and white spruce in northeastern British Columbia. Water, Air, and Soil Pollution 92:171–178.

Wang, J.R., A.L. Zhong, P.G. Comeau, M. Tsze, and J.P. Kimmins. 1996. Aboveground biomass and nutrient accumulation in an age sequence of aspen (*Populus tremuloides*) stands in the boreal white and black spruce zone, British Columbia. For. Ecol. Manage. 79:127–138.

Trofymow, J.A., P.G. Comeau, W. Kurz, and M.J. Apps. 1994. A retrospective analysis of the carbon budget for British Columbia's forest sector. Report of a joint B.C. Min. For. and Can. For. Serv. workshop, Dec. 12–13, 1994, Richmond, B.C.

FR38 Geographic variation of red alder (*Alnus rubra*) in British Columbia (E.P. 1123)

Project Leader:
Cheng Ying, B.C. Ministry of Forests, Research Branch, Victoria.

Objectives:

This study will (a) investigate the amount, distribution, and patterns of geographic variation of red alder in B.C. with respect to germination rate, seedling growth, biomass production, vegetative phenology, and nitrogen fixation; and (b) help to develop a breeding strategy.

Progress:

Seeds have been collected from 70 source locations in the natural range using a systematic sampling scheme. A common garden study was conducted in a nursery environment, field installations were established at three locations in 1995, and data collection is ongoing.

Publications:

Dang, Q.L., C.Y. Xie, C.C. Ying, and R.D. Guy. 1994. Genetic variation of ecophysiological variables in red alder *(Alnus rubra* Bong.*)*. Can. J. For. Res. 25: 567–576.

_____. [1996]. Genctic variation in ecophysiological variables in red alder. *In* Proc. Ecology and Management of B.C. Hardwoods Workshop, Dec. 1–2, 1993, Richmond, B.C. P.G. Comeau, G.J. Harper, M.E. Blache, J.O. Boateng, and K.D. Thomas (editors). Can. For. Serv. and B.C. Min. For. FRDA Rep. In press.

Xie, C.Y., C.C. Ying, and P. Courtin. 1992. Seed collection of red alder (*Alnus rubra*). B.C. Min. For., Victoria, B.C.

Xie, C.Y., C.C. Ying, and P. Courtin. [1996]. Genetic variability and performance of red alder (*Alnus rubra*) in British Columbia. *In* Proc. Ecology and Management of B.C. Hardwoods Workshop, Dec. 1–2, 1993, Richmond, B.C. P.G. Comeau, G.J. Harper, M.E. Blache, J.O. Boateng, and K.D. Thomas (editors). Can. For. Serv. and B.C. Min. For. FRDA Rep. In press.

FR42 Long-term effects of management practices on productivity of mixedwood stands in the ICH zone in the southern interior of B.C. (E.P. 1089.04)

Project Leader:
Suzanne Simard, B.C. Ministry of Forests, Kamloops Forest Region.

Objectives:

The objectives of this project are (a) to develop biomass equations applicable to a wide range of tree ages and sizes (dbh) in the Interior Cedar Hemlock zone (ICH), (b) to determine nutrient concentrations in the birch tree components, (c) to determine the nutrient capital of mineral soil and organic matter in pure birch stands, (d) to use the data collected in this study and that reported in the literature to calibrate FORECAST for pure birch and mixed birch/conifer stands in the ICH zone of the southern interior of B.C., and (e) to use the calibrated version of FORECAST to examine the effects of management practices on the long-term productivity of pure birch and mixed paper birch/conifer stands in the ICH zone of the southern interior of B.C.

Progress:

In 1991/1992 paper birch was destructively sampled on a range of sites and age classes in the ICHmw3 variant. Additional growth sampling was done in 1993/1994 to fill in gaps in the data set. Biomass equations were developed for birch across the range of site productivity and age classes sampled, and the data were used to calibrate the ecosystem model FORECAST. The results of the biomass study and the FORECAST simulations were presented at the poster session of the Hardwood Workshop in Richmond, B.C., 1993.

Publications:

Sachs, D.L. 1996. Simulation of the growth of mixed stands of Douglas fir and paper birch using the FORECAST model. *In* Proc. Silviculture of Temperate and Boreal Broadleaf-Conifer Mixtures Workshop, Feb. 28–Mar. 1, 1995, Richmond, B.C. P.G. Comeau and K.D. Thomas (editors). Land Manage. Handb. No. 36. pp. 152–158.

Wang. J.R., S.W. Simard, and J.P. Kimmins. 1995. Physiological responses of paper birch to thinning in British Columbia. For. Ecol. Manage. 73: 177–184.

Wang, J.R., A.L. Zhong, S.W. Simard, and J.P. Kimmins. 1996. Aboveground biomass and nutrient accumulation in an age sequence of paper birch (*Betula papyrifera*) stands in the Interior Cedar-Hemlock zone, British Columbia. For. Ecol. Manage. 83:27–38.

FR47 Pure and mixed paper birch stand management studies in the ICH zone in the southern interior of British Columbia: regeneration study (E.P. 1089.03)

Project Leader:
Suzanne Simard, B.C. Ministry of Forests, Kamloops Forest Region.

Objectives:

This long-term study will document the effects of species interactions between paper birch and conifer seedlings on the performance of each species and the effects of species interactions on levels of environmental resources and conditions. Models will be developed to describe the relationships between the performance of each species and the levels of environmental resources and conditions. This project will study and quantify the interaction between individual species and the mechanisms underlying those interactions in a variety of mixed stands in the ICH zone.

Progress:

Three sites were de-stumped and cleared of slash, and treatments were established and permanently marked. Soils were collected and bioassays initiated for the mycorrhizae study. Microclimate stations and decomposition stations have been installed at all sites. The three sites were planted in May and June 1992. Dead seedlings were subsequently replaced, and extra seedlings were planted for the mycorrhizae studies. All seedlings were measured immediately after planting and assessed for condition in the fall, and dead trees were marked to facilitate fill-in planting. Sample preparation was done for the leaf litter decomposition study, and mineral soil and organic matter were sampled and analyzed. A forest floor disturbance survey was conducted, a study of the ecophysiology of birch and Douglas-fir seedlings was initiated, and the bioassays of birch and Douglas-fir seedlings were completed.

Publications:

Prescott, C.E. 1996. Decomposition patterns in mixed species forests in the southern interior of British Columbia. *In* Proc. Silviculture of Temperate and Boreal Broadleaf-Conifer Mixtures Workshop, Feb. 28–Mar. 1, 1995, Richmond, B.C. P.G. Comeau and K.D. Thomas (editors). B.C. Min. For., Land Man. Handb. No. 36. pp. 159–163.

Simard, S.W. 1995. Interspecific carbon transfer in ectomycorrhizal tree species mixtures. Ph.D. thesis. Oreg. State Univ., Corvallis, Oreg.

_____. 1995. Shading influences net carbon transfer among ectomycorrhizal tree species in the field. *In* Dynamics of Physiological Processes in Woody Roots: Booklet of Abstracts, Oct. 8–11, Ithaca, N.Y. M.A. Topa, P.T. Rygiewicz, and J.R. Cummings (editors). Boyce Institute for Plant Research, U.S. Environ. Protection Agency, IUFRO Root Physiology and Symbiosis Working Party.

_____. 1996. Design of a birch/conifer mixture study in the southern interior of British Columbia. *In* Proc. Designing Mixedwood Experiments Workshop, Mar. 2, 1995, Richmond B.C. P.G. Comeau and K.D. Thomas (editors). B.C. Min. For., Victoria, B.C. Work. Pap. No. 20. 61 p.

_____. 1996. Mixtures of paper birch and conifers: an ecological balancing act. *In* Proc. Silviculture of Temperate and Boreal Broadleaf-Conifer Species Workshop, Feb. 28–Mar. 1, 1995, Richmond, B.C. P.G. Comeau and K.D. Thomas (editors). Land Manage. Handb. No. 36. pp. 15–22

_____. [1996]. Ecological and silvicultural characteristics of paper birch in the southern interior of British Columbia. *In* Proc. Ecology and Management of B.C. Hardwoods Workshop, Dec. 1–2, 1993, Richmond, B.C. P.G. Comeau, G.J. Harper, M.E. Blache, J.O. Boateng, and

K.D. Thomas (editors). Can. For. Serv. and B.C. Min. For. FRDA Rep. In press.

Wang, J.R. [1996]. Effects of climate on competitive relationships between paper birch and Douglas-fir in British Columbia. Ph.D. thesis. Univ. B.C., Vancouver, B.C. In prep.

FR47a Below-ground interactions between paper birch and Douglas-fir in the ICH zone of the southern interior of British Columbia

Project Leader:
Suzanne Simard, B.C. Ministry of Forests, Kamloops Forest Region.

Objectives:

The objectives of this study are to test the following hypotheses:

a) that the rate of initial mycorrhizal colonization (the first 2 years) is more rapid on Douglas-fir roots in mixed- than in monospecies plots, and is more rapid in Douglas-fir planted closer to birch than in those planted at greater distances; and
b) that the diversity of ectomycorrhizal fungi is higher (i) on Douglas-fir roots and (ii) in the soil in mixed plots than in monoculture.

Progress:

This study is being conducted within the paper birch mixture study (BC-FR47). In addition to above-ground interactions, both competitive and synergistic interactions occur below ground. Since sustained productivity is a goal of silvicultural practices, the role of rapidly growing broadleaves in maintaining diverse soil microfloral communities is being investigated. This project specifically investigates the role of paper birch in increasing the rate and diversity of ectomycorrhizal infection on planted conifers. It was initiated in 1991 and will continue through 1996. Soil bioassays for ectomycorrhizal fungi have been done for the paper birch/Douglas-fir mixture treatment plots in 1991. In 1992, seedlings were outplanted and then bioassays were done 1 year later to assess the rate and diversity of ectomycorrhizal infection. Data analysis was completed in 1995/1996 and results are being prepared for submission to a refereed journal. A FRDA report that integrates results of mycorrhizal diversity, carbon transfer, and growth response studies in the addition-series experiments is also being prepared. A workshop/seminar was given in 1994 and 1995.

Publications:

Durall, D.M., M.D. Jones, and S.W. Simard. [1996]. Mycorrhizal diversity in mixed and monoculture plantations of *Betula papyrifera and Pseudotsuga menziesii*. *In* Proc. Ecology and Management of B.C. Hardwoods Workshop, Dec. 1–2, 1993, Richmond, B.C. P.G. Comeau, G.J. Harper, M.E. Blache, J.O. Boateng, and K.D. Thomas (editors). Can. For. Serv. and B.C. Min. For. FRDA Rep. In press.

Jones, M.D., D.M. Durrall, M. Harniman, D. Classen, and S.W. Simard. [1996]. The ectomycorrhizal communities of *Betula papyrifera* and *Pseudotsuga menziesii* seedlings planted in pure and mixed plots in the southern interior of British Columbia. In prep.

Jones, M.D., D.M. Durall, and S.W. Simard. 1995. Ectomycorrhizal associations of birch and Douglas-fir grown in mixed or single-species plantations. *In* Dynamics of Physiological Processes in Woody Roots: Booklet of Abstracts, Oct. 8–11, 1995, Ithaca, N.Y. M.A. Topa, P.T. Rygiewicz, and J.R. Cummings (editors). Boyce Institute for Plant Research, U.S. Environ. Protection Agency, IUFRO Root Physiology and Symbiosis Working Party.

FR53 Effects of red alder density on conifer growth and nitrogen availability (E.P. 1121.01)

Project Leader:
Phil Comeau, B.C. Ministry of Forests, Research Branch, Victoria.

Objectives:

Long-term studies are required to document the effects of differing amounts of red alder on the growth of conifers, under different site conditions. Installations will be established for research and demonstration of the effects of red alder on conifer growth and nitrogen availability, and for information about the

effects of different densities and proportions of red alder on both conifer and whole-stand yield.

Progress:

An additive design is being used to study the effects of five densities of red alder (0, 50, 100, 200, and 400 trees/ha), one density of Sitka alder (200 tph), and one density of bigleaf maple (50 tph) on growth and survival of conifers (Douglas-fir and western redcedar) and on site nitrogen capital at three locations. In addition, two installations have been established to examine the dynamics of mixed stands of Douglas-fir and red alder using a replacement series design with total tree density of 742 trees/ha. Installations were planted in 1992 and 1994. Tree measurements have been collected annually in these plantations.

Publications:

Comeau, P.G. and D.L. Sachs. 1992. Simulation of the consequences of red alder management on the growth of Douglas-fir using FORCYTE-11. For. Can. and B.C. Min. For, Victoria, B.C. FRDA Rep. No. 187.

Comeau, P.G., G.J. Harper, and B. D'Anjou. 1995. Effects of red alder on stand dynamics and nitrogen availability—E.P. 1121. For. Can. and B.C. Min. For., Victoria, B.C. FRDA Memo No. 223.

Comeau, P.G., G.J. Harper, B.3. Biring, and K.D. Thomas. 1996. Field studies of red alder-conifer mixtures. *In* Proc. Designing Mixedwood Experiments Workshop, Mar. 2, 1995, Richmond, B.C. P.G. Comeau and K.D. Thomas (editors). B.C. Min. For., Victoria, B.C. Work. Pap. No. 20. 61 p.

III. Forest Renewal BC: Mixedwood Management Research 1995–1996

H02 Acquisition of ecologically based site index information for B.C. hardwoods

Project Leader:

Phil Comeau, B.C. Ministry of Forests, Research Branch, Victoria, B.C.

Objectives:

This project has two major objectives: (a) to develop site index curves for B.C. broadleaves; and (b) to collect and summarize site-index-site-series data for four B.C. broadleaf species (red alder, paper birch, black cottonwood, and balsam poplar).

Progress:

Existing information about site-index-site-series relationships for red alder, paper birch, black cottonwood, and balsam poplar has been compiled and summarized in a draft report that is being circulated for technical review.

H04 Calibration of TASS for red alder and development of preliminary managed stand yield tables

Project Leaders:

Ken Mitchell, B.C. Ministry of Forests, Victoria, B.C.

Phil Comeau, B.C. Ministry of Forests, Research Branch, Victoria, B.C.

Albert Nussbaum, B.C. Ministry of Forests, Victoria, B.C.

Objectives:

To calibrate TASS and use the model to generate managed-stand yield tables for red alder.

Progress:

Detailed stem and branch data were collected from 15 red alder trees. TASS was upgraded to simulate leaning trees and preliminary parameterization of TASS for red alder was completed. Red alder provenance and Nelder plots at the UBC Research Forest (Haney) were remeasured to provide initial

calibration data. Calibration of TASS will be completed after these data have been summarized.

H05 Effects of spacing of paper birch on birch growth and on understory conifer growth at Spey Creek (E.P. 1193)

Project Leaders:
Jian Wang, B.C. Ministry of Forests, Red Rock Research Station, Prince George.
Phil Comeau, B.C. Ministry of Forests, Research Branch, Victoria.
Dave Coopersmith, B.C. Ministry of Forests, Prince George Region.

Objectives:
The objectives of this study are
a) to evaluate and demonstrate the effects of juvenile spacing on growth of paper birch and on understory conifers;
b) to measure (estimate) leaf area index (LAI) of the birch canopy to determine the effect of spacing on LAI and its spatial distribution;
c) to document changes in LAI over the growing season during selected years and its change over time; and
d) to document light conditions underneath birch stands of different densities following spacing treatments.

Progress:
The study site at Spey Creek (Prince George Forest District) is a portion of a larger opening that includes a sizable area of 30-year-old paper birch. Birch are approximately 15 m tall. The portion of this block selected for the trial has approximately 3000 trees per hectare of paper birch, with an equal amount of willow and some trembling aspen and black cottonwood. The dense coniferous understory is dominated by subalpine fir and white spruce, with a minor component of Douglas-fir and lodgepole pine. Each of the following four main treatments were replicated four times: 1) untreated control; 2) space to 1200 birch/ha; 3) space to 600 birch/ha; and 4) complete removal of birch. Eighty- by eighty-metre (0.64 ha) plots have been established for each main treatment, and understory conifers were spaced to 1200 trees/ha. Plot layout, treatment application, and 1st-year measurements were completed in November 1995.

H06 Effects of hardwood density and arrangement on mixed stand development (E.P. 1121.02)

Project Leader:
Phil Comeau, B.C. Ministry of Forests, Research Branch, Victoria.

Objectives:
The objectives of this study are (a) to complete development of a model for estimating light penetration through broadleaf canopies; (b) complete calibration and validation of the light model for several broadleaf species (red alder, bigleaf maple, paper birch, and trembling aspen); (c) acquire and analyze data about responses of understory conifers to the density and arrangement of overtopping broadleaves and light levels; (d) to develop models for predicting responses of understory conifers; and (e) to establish and conduct field trials to document responses of conifers to different densities and arrangements of broadleaves.

Progress:
During 1995/1996, long-term field studies were established to examine the following: (1) effects of maple density and spacing on performance of a mixed stand of Douglas-fir and bigleaf maple (Port Alberni Forest District); and (2) effects of paper birch density on performance of overtopped white spruce and subalpine fir (Prince George Forest District). Each of these studies involve treatments that manipulate the density and spacing of the broadleaf component and measurement of the growth response of both conifers and broadleaves, stand development (measurement of fixed-area plots), and measurements of light reaching understory conifers. Data from these studies will help develop models for predicting survival and growth responses of understory conifers. Work during 1996 will focus on testing and refining the light model and on evaluating various methods for measuring light.

H07 Vegetation management options for establishment of hybrid poplar plantations and their effect on nutrient cycling (E.P. 1135.04)

Project Leader:
Keith Thomas, B.C. Ministry of Forests, Research Branch, Victoria.

Objectives:

The objectives of this study are

a) to evaluate the effectiveness of polyethylene mulch mats and Vision® herbicide on hybrid poplar growth and survival; and
b) to evaluate the effectiveness of two types of mulch mats of varying sizes on hybrid poplar growth and survival.

Progress:

Successful establishment of hybrid poplars on both agricultural and forest lands requires intense pre-planting site preparation followed by weed control for at least 2 years. Traditionally, herbicides such as Vision® or Roundup® have been used in poplar plantations in B.C. However, application of herbicides is not permitted in areas with standing water or in areas close to streams. Also, some farmers and land owners do not wish to use herbicides. There is also concern that short rotations may remove nutrients too quickly, thereby compromising site productivity and sustainability. This experiment provides an opportunity to address these concerns. To date, no such studies have been conducted in B.C. This study will evaluate and demonstrate the effectiveness of plastic mulch mats and Vision® herbicide treatments for weed control in hybrid poplar plantations, evaluate the impact of these treatments on poplar performance, and improve our understanding of nutrient cycling in hybrid poplar plantations. Plots were established and treatments were applied in the spring of 1995. The 1st-year's growth data have been analyzed and are presented in an establishment report.

H08 Development, calibration and evaluation of FORECAST and FORTOON for mixedwood management simulations

Project Leader:
J.P. (Hamish) Kimmins, University of B.C., Faculty of Forestry, Department of Forest Sciences, Vancouver, B.C.

Objectives:

Project objectives are to develop, calibrate, and test FORECAST and FORTOON for simulating mixedwood stands in B.C., and to use the model to examine the effects of various mixedwood management options.

Progress:

A new modelling strategy was launched that borrows from the modelling approaches and philosophies developed in FORCYTE and FORECAST. The product was a working prototype of an individual-tree, spatially explicit, and stand-level ecosystem management model, FORCEE 1.0. In addition to software development, calibration data for lodgepole pine ecosystems, birch/Douglas-fir ecosystems, spruce/aspen ecosystems, and Douglas-fir/red alder ecosystems are being collected. A prototype approach was also developed to incorporate moisture and temperature representations that will permit the software to examine the robustness of mixedwood management strategies in the face of climate change scenarios. Three workshops were held at UBC to review programs and guide software development, and to review the conceptual models on which this development was based.

H09 Asexual propagation of trembling aspen (*Populus tremuloides*)

Project Leaders:
Timothy Conlin, B.C. Ministry of Forests, Glyn Road Research Station, Victoria, B.C.
Robert van den Driessche, B.C. Ministry of Forests, Glyn Road Research Station, Victoria, B.C.

Objectives:

The objectives of this study are

a) to quantify thermal time needed for suckering in aspen roots under controlled conditions and in field trials;
b) to quantify the effect of mechanical damage on suckering potential of aspen; and
c) to use results to modify silvicultural practices and to design harvest and site preparation machinery.

Progress:

This study examines the impact of changes in soil thermal properties that accompany soil compaction and hydrological changes. Soil temperature appears to be the major factor influencing sucker initiation and growth in intact aspen roots; it is likely that thermal time ($°C\ days^{-1}$) could be used to predict aspen stand regeneration potential and early stand development. Such information will be used by foresters to predict regeneration times for aspen-dominated forest ecosystems in British Columbia. The second component of this experiment is studying the effect of crushing and severing suffered by roots of aspen when the timber is harvested with machinery. The physical changes in soil compacted by machinery, specifically the impeded diffusion of oxygen to respiring roots, is also being studied. Preliminary data indicate that the crushing of only a portion of the root prevents suckering, while a cleanly cut root suckers normally. This research project is designed to provide information that will allow the forest manager to avoid damaging the asexual regeneration capacity of aspen stands (i.e., information that will contribute to improved harvest techniques and site preparation practices). To date, two experiments have been completed: one experiment on the effect of thermal time on aspen suckering; and one experiment on the effect of mechanical damage on aspen suckering. Five male and female clones have been selected as source material for upcoming experiments. Data have been entered into spreadsheets but have not yet been analyzed.

H12 Hybrid poplar nutrition studies

Project Leaders:

Robert van den Driessche, B.C. Ministry of Forests, Glyn Road Research Station, Victoria, B.C.

Objectives:

The objectives of this project are to study (a) the mineral nutrition of hybrid poplars to determine optimal nutrient treatments for poplars management; (b) Phosphorus nutrition; and (c) the interactions of nutrition with water use, and the effects on poplar clones.

Progress:

Poplar on Vancouver Island have shown deficiencies, particularly of phosphorous, and must have good drought resistance to be productive. It is essential to determine the optimum leaf nutrient concentrations if maximum yield is to be obtained. Clone, level of nutrient supply, and moisture supply must be jointly considered, because these may all influence the optimum nutrient concentration necessary for maximum yield. The plots were laid out on a 6-ha experimental site near Qualicum, B.C. in the spring of 1995. Pretreatment measurements were done and the 1st year's growth data were collected and analyzed. In addition, leaves and soil were periodically sampled throughout the growing season. Preliminary analysis of growth has been done but results are premature for any definitive conclusions.

H13 Effects of P and N nutrition on the growth and gas exchange of hybrid poplars during establishment: implications for long-term growth

Project Leader:

Kevin Brown, B.C. Ministry of Forests, Research Branch, Glyn Road Research Station, Victoria, B.C.

Objectives:

The objectives of this study are

a) to assess the effects of Phosphorous (P) and Nitrogen (N) fertilization on leaf area production, light interception, and photo-

synthesis in relation to growth of poplar hybrids during the establishment year;
b) to assess the relationship of the 1st-year growth and photosynthesis with growth after 3 years;
c) to determine if clones differ in rooting following planting and if rooting is related to concentrations of N, P, and specific carbohydrates in the cuttings before planting; and
d) to determine if root production proliferates in response to increased localized supplies of P, and to determine if the response varies with clone.

Progress:
Phosphorus deficiencies may limit growth of poplar plantations on the east coast of Vancouver Island, and clones of hybrid poplar may differ in their response to N and P availability; however, the mechanisms underlying these clonal differences are not well understood. An understanding of clonal differences in rooting and growth responses to P and N additions is required as a basis for clonal selection and for the refinement of management practices. This study was initiated in the spring of 1995. Leaf areas were estimated in July–early August using regression analysis. Leaf measurements were made in conjunction with other morphological measurements necessary for calculations of light interception by the Ecophys growth model. Photosynthesis was measured in early September following cessation of growth of leaves, and rates varied little across treatments. Rooting of six clones was compared, and it was observed that root length and total number of root tips varied with clone. Height growth of the clones was also measured over time, and it was found that the magnitude of response to fertilization (diammonium phosphate [DAP] triple superphosphate [TSP]) varied with clone.

H14 Assessment of potential nutritional deficiencies in red alder stands

Project Leader:
Kevin Brown, B.C. Ministry of Forests, Glyn Road Research Station, Victoria, B.C.

Objectives:
The objectives of this study are
a) to assess the effect of fertilization with phosphorous (P) and lime on the growth and mineral nutrition of red alder seedlings in soils collected from mature red alder stands; and
b) to assess the effect of initial soil pH on the growth and mineral nutrition responses to P and lime additions.

Progress:
Soil was collected from six locations on Vancouver Island: four to the west of Lake Cowichan and two to the north of Campbell River. The soils were analyzed, and all were classified as nutrient very rich. In the first experiment, red alder seedlings were grown in one soil type and 12 treatments of P and lime were applied. Results indicate that red alder did respond to applications as high as 50 kg P/ha, and lime appeared to have no effect on seedling growth. A second study was initiated in which red alder seedlings were planted in the six soil types, and six treatment combinations of P and lime were applied. Response data are not yet available.

H17 Regenerating boreal mixedwood

Project Leader:
Richard Kabzems, B.C. Ministry of Forests, Fort St. John District, Prince George Forest Region.

Objectives:
The objectives of this study are
a) to compare artificial spruce regeneration growth performance under varying levels of aspen residual canopies, with and without mechanical site preparation;
b) to compare degrees of spruce natural regeneration achieved under the above conditions;
c) to determine the degree of release and windfirmness of advanced spruce regeneration;
d) to document aspen regeneration growth with full canopy removal;
e) to compare vegetation growth and dynamics in the conditions described above;
f) to provide local data for the formulation of guidelines for mixedwood management; and

g) to provide instruction about executing mixedwood harvesting through extension events.

Progress:

The harvest of mixed species stands in the boreal forest will increase, and as a result it will be ecologically desirable to regenerate these harvested stands to true mixedwoods, rather than to stands dominated by a single species. This study addresses the problem of simultaneous regeneration of mixedwoods following harvesting. Three suitable mixedwood stands were selected in 1995. One of these stands will be harvested as a demonstration in the winter of 1995–1996. The remaining two stands will be logged as part of the research project during the winter of 1996–1997. The model for harvesting and regeneration will divide each of the three stands into three zones. Zone 1 will be composed of concentrations of spruce advanced regeneration from which overtopping commercial aspen and spruce are removed. Zone 1 will be used to study windfirmness, release, and vegetation dynamics in the residual spruce. Zone 2 will surround Zone 1 areas, and will consist of partial canopies of residual aspen. Zone 2 will be used to study spruce artificial and natural regeneration under varying canopies, with and without site preparation, and vegetation dynamics. Zone 3 will be composed of areas where the tree canopy has been completely removed to create full light conditions. Aspen regeneration and vegetation dynamics will be studied in Zone 3. Once the research sites have been established and logged, annual measurements will be taken for 5 years, and then every 3 years to year 15, and, finally, every 5 years to year 50. Statistical analyses will include analysis of variance, regression, and χ^2.

H19 Dynamics of young Sub-Boreal Spruce mixedwood ecosystems

Project Leaders:

Dave Coopersmith, B.C. Ministry of Forests, Prince George Forest Region.

Art Ferdeen, University of Northern B.C., Prince George, B.C.

Mike Walters, University of Northern B.C., Prince George, B.C.

Objectives:

a) To determine the contributions of broadleaf species to soil organic matter dynamics, nutrient cycling, and soil/site productivity in these plantations;
b) to determine the effects of the presence and density of broadleaf trees on conifer and broadleaf growth and yield;
c) to determine the effects of broadleaf species on insect damage, incidence of root disease, and wildlife damage to the conifers;
d) to determine the effect of defoliation of overstory broadleaf trees by insects and the subsequent effects on conifers;
e) to determine stand structure/density effects on wildlife habitat usage and wildlife diversity;
f) to determine the effects of broadleaf tree density manipulation on herbaceous and shrub communities, and on broadleaf-tree suckering or sprouting success;
g) to determine the optimum densities of broadleaf trees required to maximize crop tree (conifer and broadleaf) growth and yield in these plantations; and
h) to determine the effect of overtopping broadleaf trees on the abiotic variables of light, humidity, and CO_2 concentration.

Progress:

This project was initiated in 1995. One site near Prince George was selected and research plots were established. Baseline data have been collected and treatments applied. Collection and analysis of data is ongoing.

H23 Crop tree response to brushing at various radii in the Mixed- Hardwood Complex in the southern interior of B.C.

Project Leader:

S. Simard, B.C. Ministry of Forests, Kamloops Forest Region.

Objectives:

The objectives of this study are

a) to determine the brushing radius for optimal plantation performances on a range of sites;
b) to determine the response of non-crop vegetation to different removal methods; and

c) to provide districts with guidelines on point cleaning of mixed broadleaf species in order to establish healthy, productive broadleaf/conifer mixtures.

Progress:

Paper birch commonly grows in intimate mixture with Douglas-fir in young plantations. While it competes for light and other resources, birch also has been demonstrated to be a source of nutrients, a host to a diverse community of microbes and mycorrhizal fungi, and resistant to common Interior Cedar-Hemlock (ICH) root pathogens. Silviculturalists are struggling to establish healthy mixtures of birch and conifers that do not unduly compromise the growth and quality of the commercially valuable conifers. Intimate mixtures are difficult to maintain on an operational basis (individual tree management) because of their spatial complexity. An alternative approach is to remove paper birch to a fixed distance around individual conifers (i.e., point cleaning). The appropriate brushing radius for optimal health and productivity of the plantation are unknown, and likely change with age and site quality. This proposed study compares a range of brushing radii across a range of sites (ICHmw in Clearwater, Salmon Arm, and Vernon districts) using a variety of birch removal methods (manual cutting in year 1, manual cutting for 2 consecutive years, and cut-stump in year 1). Sites have been selected and the installations established. Crop trees and target non-crop trees have been assessed and tagged, and neighbourhood understory vegetation has been measured.

H24 The role of hardwoods in sustaining site productivity in Interior Cedar-Hemlock stands

Project Leaders:

Graeme Hope, B.C. Ministry of Forests, Kamloops Forest Region.

Suzanne Simard, B.C. Ministry of Forests, Kamloops Forest Region.

Objectives:

The objectives of this study are

a) to compare the effects of pure birch, mixed conifer-birch, and pure conifer on the soil processes controlling long-term site productivity;
b) to compare the effects of stand density and age of stand on the processes controlling long-term site productivity; and
c) to quantify the immediate and long-term effects of birch removal on site productivity.

Progress:

In the productive Interior Cedar-Hemlock (ICH) forests of the southern Interior, naturally regenerated stands historically contain a component of broadleaves, predominantly birch. In the recent past, however, much of the management of these forests has been focused on maximizing conifer sawlog production. Because of concerns about forest health, biodiversity, and sustained site productivity, attention is now turning to the role of broadleaves in these mixedwood forests. Although broadleaf species are now acceptable in silvicultural prescriptions, many questions remain about the optimum densities of broadleaves in mixed stands to both sustain site productivity and maximize fibre production. There are also harvesting-related questions regarding time of removal of broadleaves and whether the broadleaf species leave a legacy of improved site productivity. In order to advance our understanding and management of mixed stands, this study will investigate the processes controlling sustained productivity in older stands. Two experiments will be conducted using some sites for both. One experiment will compare managed and unmanaged 30-year-old stands; the second will compare unmanaged chronosequences of stands at three different sites in the ICH zone. Three types of forest stands will be investigated: pure paper birch, pure Douglas-fir, and a paper birch—Douglas-fir mixture. For the first investigation, there will be two managed treatments: stumped and planted, and no stump removal and planted. For the second study, two other natural stands will also be located in the same areas as the 30-year-old stands, with ages of approximately 50 and 100 years. This will allow comparison of three unmanaged chronosequences. Twenty-seven study sites were selected, representing four stand ages, and three tree species replicated three times. Intensive sampling and measurements will begin in 1996.

H25 Development of guidelines for managing density, proximity and species composition in birch/conifer mixtures in the southern Interior: a retrospective approach

Project Leader:
Suzanne Simard, B.C. Ministry of Forests, Kamloops Forest Region.

Objectives:

The objectives of this study are

a) to determine the effects of species, amount, size, and proximity of neighbours on the size of target conifers (e.g., Douglas-fir, western redcedar, and western larch) across a range of age classes (e.g., 10±5 years, 30±5 years, and 50±5 years) on circum-mesic sites in the ICH zone; and
b) to develop guidelines for managing density, proximity, and species composition in birch/conifer mixtures in the ICH zone.

Progress:

Considerable controversy continues to surround management of birch/conifer mixtures. Although most silviculturalists agree that some birch retained in conifer plantations is ecologically beneficial, there is little agreement about the specific densities, proportions, and proximity to neighbouring conifers. This study uses the neighbourhood approach, which has previously been applied with considerable success. The neighbourhood approach is tree-centred, wherein the performance of a conifer (in this case) is related to the density, proximity, and size of its neighbours. The main advantage of the approach is that predictive models can be developed relatively quickly. The main disadvantages are that (a) conifers may be responding primarily to factors (which may be very obscure) other than neighbouring vegetation, and (b) the analysis represents only one moment in time. These problems can be minimized by including several replicate sites within an age and site group, and by examining chronosequences. Twenty-seven study sites (3 species*3 age classes *3 replicates = 27) will be sampled over a 3-year period. Using neighbourhood and light parameters, several published competition indices will be calculated. The indices essentially quantify the amount of interference a target tree is experiencing from neighbouring vegetation. Regression models will then be constructed relating target tree performance to the competition indices. The utility of the models will be evaluated based on the amount of variation in target tree performance that is explained, their universal application across all situations, and their simplicity. Nine sites (three species replicated three times) have been sampled in the 10-year-old age class. The data are currently being analyzed.

H27 Relationship between aspen site index and measures of ecological site quality

Project Leader:
Richard Kabzems, B.C. Ministry of Forests, Prince George Forest Region.

Objectives:

The objectives of this study are

a) To determine aspen site index and its relationships between categorical and continuous measures of ecological site quality in the Boreal White—Black Spruce (BWBS) zone of northeastern B.C.;
b) to assess to what extent soil nutrient properties support differentiation of field-identified soil nutrient regimes in aspen ecosystems; and
c) to assess the predictive value of a combination of soil nutrient and physical properties (aeration, porosity, bulk density) for determining site index of trembling aspen.

Progress:

Existing files of aspen permanent sample plots (PSP) in the inventory program in each of the three Peace/Liard districts was compiled. Candidate study sites were selected and a site classification-age matrix was prepared. Sixty sites were selected and data were collected about soils and stem analysis. Height/age and site index functions were also developed. In the upcoming year, soils and foliage will be analyzed and up to 75 more sites in the BWBS will be selected and sampled.

H28 Influence of species mixtures on litter decomposition in forests of British Columbia

Project Leader:
Cindy Prescott, University of B.C., Faculty of Forestry, Department of Forest Sciences, Vancouver, B.C.

Objectives:

The objectives of this study are

a) To measure rates of decay of foliar litter of each species alone and mixed with litter from other species, to determine if mixing litters influences decay rates of these species;
b) to measure rates of decay of foliar litter on forest floors of each species, to determine if the forest floor that develops under different species influences the rate of litter decomposition; and
c) to measure rates of decay of foliar litter in single-species and mixed plots to determine if the forest floor in mixed plots influences rates of decay.

Progress:

Increasing interest in the management of mixedwood forests in B.C. has highlighted our limited understanding of the interactions among species in mixed forests, particularly about belowground processes and nutrient cycling with respect to foliar litter decomposition. Decomposition experiments were established in the three major types of mixedwood forests in B.C.: (1) Douglas-fir and red alder in the Coastal Western Hemlock zone; (2) Pine, birch and Douglas-fir in the Interior Cedar Hemlock zone; and (3) Spruce and aspen in the Boreal White and Black Spruce zone. The data collected from these experiments will be used to create a default sub-routine for decomposition in the FORECAST model, and will improve the model's representation of mixedwood forests. This will allow model users to calculate rates of decomposition that are based on climate and litter chemistry data specifically calibrated for B.C.'s forests, thereby circumventing the need for time-consuming decomposition experiments. Sample collection and data processing is currently under way.

H29 Seasonal ecophysiology of western redcedar under an alder canopy: Sunfleck use efficiency and rhodoxanthin accumulation

Project Leaders:
Robert Guy, University of B.C., Faculty of Forestry, Department of Forest Sciences, Vancouver, B.C.
Leanne McKinnon, University of B.C., Faculty of Forestry, Department of Forest Sciences, Vancouver, B.C.

Objectives:

a) To characterize sunfleck regimes under red alder canopies and to use this information to estimate the potential limitation to summer carbon gain imposed by the fluctuating light environment;
b) to quantify and contrast the sunfleck-use efficiencies of western redcedar and coastal Douglas-fir saplings growing under red alder canopies;
c) to identify, quantify, and contrast physiological limitations to sunfleck-use efficiency in western redcedar and coastal Douglas-fir;
d) to quantify and provide time-courses of any seasonal changes in rhodoxanthin content in western redcedar saplings in the field, particularly during and after exposure caused by canopy leaf-fall; and
e) to determine if rhodoxanthin pigment can protect the photosynthetic capacity of western redcedar against the interactive autumnal effects of decreasing air temperature and exposure caused by canopy leaf-fall (growth chamber experiment).

Progress:

This study evaluates the effects of established mixedwood systems on the photosynthetic activity of the conifer component. This was accomplished using two non-conventional *in situ* measures of light-use efficiency and rhodoxanthin pigment content of western redcedar in the understory of red alder. Two comparable experimental sites have been selected, one in Dewdney, B.C. and the other at the UBC research forest (Maple Ridge).

Experimental conditions for the gas exchange studies (sunfleck-use efficiency) were defined in the field. Western redcedar foliage was collected and analyzed for chlorophyll fluorescence parameters, rhodoxanthin, and other pigments. Photodiodes and fish-eye photographs will be used to help characterize understory light and sunfleck activity of the alder canopy. A laboratory experiment is also running concurrently in which the role of rhodoxanthin in protecting western redcedar from seasonal cycles of light exposure is being tested.

H30 The impact of vine maple on forest soils and nutrient cycling in southwestern B.C. forests

Project Leader:
Margaret Schmidt, Simon Fraser University, Department of Geography, Burnaby, B.C.

Objectives:
The objectives of this study are
a) To gather preliminary data and information about vine maple gaps to facilitate planning of effective and statistically powerful future studies of vine maple gaps; and
b) to determine if vine maple improves soil fertility.

Progress:
Vine maple (*Acer circinatum*) is a unique and little-studied broadleaf species that contributes to the biodiversity of forest ecosystems on the southwest coast of B.C. This species is thought to have a base-rich litter with the potential to contribute to the availability of nutrients in relatively nutrient-poor ecosystems. In order to study the effect of vine maple on soil properties of forest gaps, research plots were established at the Seymour Demonstration Forest. Soil moisture and temperature and rates of litterfall and litter decomposition were monitored for 2 years. Forest floor and mineral soil samples were collected and analyzed for macro-nutrients. The findings of this study will be published in a Master's thesis in the fall of 1996.

H31 The role of vine maple gaps in sustaining forest productivity

Project Leader:
Margaret Schmidt, Simon Fraser University, Department of Geography, Burnaby, B.C.

Objectives:
The objective of this study is to examine the growth of Douglas-fir (*Pseudotsuga menziesii*) and western hemlock (*Tsuga heterophylla*) surrounding vine maple gaps and to compare their growth rates with similarly aged trees growing within a stand.

Progress:
Vine maple (*Acer circinatum*) is a unique and little-studied broadleaf species that is commonly found in gaps of conifer forests of the Pacific Northwest. This study was carried out in two stands at the Seymour Demonstration Forest: a Douglas-fir dominated stand and a western hemlock dominated stand. Twenty-one pairs of plots were established: one plot in the gap, and the other under the conifer canopy. The trees in each of the plots were assessed for age, size, canopy structure, and growth history. This project will provide basic ecological information about the productivity of these gap environments and their effect on tree growth. The findings of this experiment will be presented in a Master's Thesis in the fall of 1996.

H33 Pathological investigations into the causes of redheart in red alder

Project Leaders:
Eric Allen, Canadian Forest Service, Pacific Forestry Centre, Victoria, B.C.

Objectives:
The purpose of this study is to investigate the redheart condition in coastal mainland alder and to determine the factors contributing to its occurrence.

Progress:
Redheart is a term used to describe a reddish discolouration of red alder wood. It is

usually formed in response to a number of factors including fungal infection and physical damage (e.g., frost cracks), and possibly to physiological stress. Wood infected with redheart is significantly under-valued in the alder industry; therefore, a better understanding of this phenomenon is paramount in managing infected red alder stands, especially with respect to predicting their standing value. The geographic distribution of redheart in alder stands on the B.C. southern Mainland was assessed, and red alder was also sampled along the south Coast for the prevalence of redheart in different age classes. The spatial distribution of redheart within infected stands was analyzed, and temperature and outflow events were recorded in the Southgate River valley and Toba valley from November 1995 to March 1996. The findings of this study are being written and formatted for publication in a scientific journal.

H34 Pathogenic impact and biology of an Eriophyidae mite (Gen. et sp. nov.) causing bronze leaf, a new hybrid poplar foliage disease

Project Leaders:

Valin Marshall, Canadian Forest Service, Pacific Forestry Centre, Victoria, B.C.
Brenda Callan, Canadian Forest Service, Pacific Forestry Centre, Victoria, B.C.

Objectives:

The objectives of this study are

a) to determine the pathogenic effect of bronze leaf to hybrid poplar plantations; and
b) to describe the new species of mite responsible for this disease and to determine the disease cycle, as a prerequisite for developing control methods or selecting resistant hybrid poplars.

Progress:

Hybrid poplar plantation managers are concerned with the deleterious effects that heavy mite infestations may have on susceptible clones where the mite is found, and with its ability to spread amongst plantations. A preliminary survey of Vancouver Island has documented three geographic occurrences of the poplar leaf-bronzing mite, and samples of mites were collected from sites near Duncan, Union Bay, and Sayward. A major focus of research in 1996/1997 is to determine the biology of this mite. One thousand one hundred and fifty-two trees in a 4-year-old plantation established by MacMillan Bloedel were evaluated for mite infestation. Preliminary sampling of leaves, twigs, and bark from native black cottonwood near Chemainus, B.C. was conducted to determine the overwintering locations of the mite. A systematic sampling of twigs from hybrid poplars at MacMillan Bloedel's poplar plantation near Kelsey Bay was conducted to elucidate the overwintering habits of the mite. In addition, poplar cuttings were planted in a greenhouse in preparation for next year's field season. This study is ongoing.